Notice No.2

Rules and Regulations for the Classification of Naval Ships, January 2020

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2020

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Volume 2, Part 8, Chapter 1, Sections 1–6 and 8-11	1 July 2020	N/A
Volume 2, Part 8, Chapter 2, Sections 1–4, 6, 7 and 10	1 July 2020	N/A
Volume 2, Part 9, Chapter 1, Section 1	1 July 2020	N/A
Volume 2, Part 9, Chapter 2, Section 7	1 July 2020	N/A
Volume 2, Part 9, Chapter 12, Section 1	1 July 2020	N/A

Lloyd's Register

Volume 2, Part 8, Chapter 1
Steam Rising Plant and Associated Pressure Vessels

■ *Section 1*
General requirements

1.2 Definition of symbols

(Part only shown)
1.2.1 The symbols used in the various formulae in *Vol 2, Pt 8, Ch 1, 2 Cylindrical shells and drums subject to internal pressure*, unless otherwise stated, are defined as follows and are applicable to the specific part of the pressure vessel under consideration:

c = corrosion allowance in mm for design and operating condition taking into account the intended life cycle; a minimum corrosion allowance of 0,75 mm is to be used, any deviation is to be agreed with LR taking into consideration the material type, service fluid, design and operating conditions. The corrosion allowance is to be added to the calculated Rule thickness as well as to the minimum thickness specified by the Rules.

1.2.2 Where reference is made to calculated or actual plate thickness for the derivation of other values, these thicknesses are to be minus the ~~standard Rule~~ corrosion allowance ~~of 0,75 mm, if not so stated~~ (*c*).

■ *Section 2*
Cylindrical shells and drums subject to internal pressure

2.1 Minimum thickness

(Part only shown)
2.1.1 Minimum thickness, *t*, of a cylindrical shell is to be determined by the following formula:

$$\cancel{t = \frac{pRi}{\sigma\ J - 0{,}5p} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{pR_i}{\sigma\, J - 0{,}5p} + c}$$

where *t*, *p*, R_i, *c* and σ are defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

■ *Section 3*
Spherical shells subject to internal pressure

3.1 Minimum thickness

3.1.1 The minimum thickness of a spherical shell is to be determined by the following formula:

$$\cancel{t = \frac{pRi}{2\,\sigma\ J - 0{,}5p} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{pR_i}{2\,\sigma\, J - 0{,}5p} + c}$$

where *t*, *p*, R_i, *c*, σ and *J* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*.

■ *Section 4*
Dished ends subject to internal pressure

4.1 Minimum thickness

(Part only shown)
4.1.1 The thickness, *t*, of semi-ellipsoidal and hemispherical unstayed ends, and the knuckle section of torispherical ends, dished from plate, having pressure on the concave side and satisfying the conditions listed below, is to be determined by the following formula:

$$\cancel{t = \frac{p\,Do\,K}{2\,\sigma\ J} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{p\,D_o\,K}{2\,\sigma\,J} + c}$$

where

= t, p, D_o, c, σ and J are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*.

4.1.4 In addition to the formula in *Vol 2, Pt 8, Ch 1, 4.1 Minimum thickness 4.1.1* the thickness, t, of a torispherical head, made from more than one plate, in the crown section is to be not less than that determined by the following formula:

$$\cancel{t = \frac{pRi}{2\,\sigma\,J - 0{,}5p} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{pR_i}{2\,\sigma\,J - 0{,}5p} + c}$$

where

= t, p, R_i, c, σ and J are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

■ *Section 5*

Conical ends subject to internal pressure

5.2 Minimum thickness

(Part only shown)

5.2.1 The minimum thickness, t, of cylinder, knuckle and conical section at the junction and within the distance, L, from the junction is to be determined by the following formula:

$$\cancel{t = \frac{p\,Do\,K}{2\,\sigma\,J} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{p\,D_o\,K}{2\,\sigma\,J} + c}$$

where t, p, σ, c and J are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

(Part only shown)

5.2.3 The minimum thickness, t, of those parts of conical sections not less than a distance, L, from the junction with a cylinder or other conical section is to be determined by the following formula:

$$\cancel{t = \frac{pD_c}{(2\sigma J - p)}\frac{1}{\cos\alpha} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{pD_c}{2\sigma J - p}\frac{1}{\cos\alpha} + c}$$

where

α, α_1, α_2 = angle of slope of conical section (at the point under consideration) to the vessel axis, *see Figure 10.5.1 Conical ends and conical reducing sections*

c is as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*.

■ *Section 6*

Standpipes and branches

6.1 Minimum thickness

(Part only shown)

6.1.1 The minimum wall thickness of standpipes and branches is to be not less than that determined by *Vol 2, Pt 8, Ch 1, 7.1 Minimum thickness* increased by the addition of a corrosion allowance ~~of 0,75 mm~~ (c as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols 1.2.1*), making such additions as may be necessary on account of bending, static loads and vibration. The wall thickness, however, is to be not less than:

t = 0,015D_o + 3,2 mm

■ *Section 8*
Headers

8.2 Rectangular section headers

(Part only shown)
8.2.1 The thickness of the flat walls of rectangular section headers is to be determined at the centre of the sides, at all the lines of holes and at the corners. The minimum required is to be the greatest thickness determined by the following formula:

$$\cancel{t = \frac{pn}{2\sigma J} + \sqrt{\frac{4Yp}{\sigma J_1}} + 0{,}75 \text{ mm}}$$

$$\boxed{t = \frac{pn}{2\,\sigma\,J} + \sqrt{\frac{4\,Yp}{\sigma\,J_1}} + c}$$

where
Y = a coefficient determined in accordance with *Vol 2, Pt 8, Ch 1, 8.2 Rectangular section headers 8.2.2*. In all cases if the value of Y is negative, the sign is to be ignored.
c is as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

8.3 Toroidal furnace headers

(Part only shown)
8.3.1 The minimum thickness of a toroidal header forming the lower end of a waterwall furnace, and supporting the weight of the boiler and water, is to be determined by the following formula:

$$\cancel{t = A + \sqrt{A2 + \frac{4M}{JS\sigma}} + 0{,}75 \text{ mm}}$$

$$\boxed{t = A + \sqrt{A^2 + \frac{4M}{J\,S\,\sigma}} + c}$$

= t, p, c and σ are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

$$\cancel{M = \frac{Wr}{3} - \frac{pd2r}{4} \text{ Nmm}}$$

$$\boxed{M = \frac{Wr}{3} - \frac{p\,d^2 r}{4} \text{ Nmm}}$$

8.4 Header ends

(Part only shown)
8.4.3 Ends attached by welding are to be designed as follows:

- Dished ends: these are to be in accordance with *Vol 2, Pt 8, Ch 1, Ch 10, 4.1 Minimum thickness*
- Flat ends: the minimum thickness of flat end plates is to be determined by the following formula:

$$\cancel{t = di\sqrt{\frac{10p\,C}{\sigma}} + 0{,}75\,mm}$$

$$\boxed{t = d_i\sqrt{\frac{10p\,C}{\sigma}} + c}$$

= where p, c and σ are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

■ *Section 9*
Flat surfaces and flat tube plates

9.1 Stayed flat surfaces

(Part only shown)
9.1.6 The thickness, t, of those portions of flat plates supported by stays and around tube nests is to be determined by the following formula:

$$\cancel{t = Cd\sqrt{\frac{10p}{\sigma}} + 0{,}75\,mm}$$

$$\boxed{t = Cd\sqrt{\frac{10p}{\sigma}} + c}$$

= where t, p, c and σ are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

9.4 Flat plate margins

(Part only shown)

9.4.1 The width of margin, *b*, of a flat plate which may be regarded as being supported by the shell, furnaces or flues to which the flat plate is attached is not to exceed that determined by the following formula:

$$\cancel{B = C(t - 0{,}75)\sqrt{\frac{\sigma}{10p}}\ \text{mm}}$$

$$\boxed{b = C(t - c)\sqrt{\frac{\sigma}{10\,p}}\ \ mm}$$

= where p, c and σ are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

■ *Section 10*
Flat plates and ends of vertical boilers

10.1 Tube plates of vertical boilers

(Part only shown)

10.1.1 Where vertical boilers have a nest or nests of horizontal tubes, so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates in way of the outer rows of tubes is to be determined by the following formula:

$$\cancel{t = \frac{p\,D}{0{,}5 J\,R20} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{2\,p\,D}{J\,R_{20}} + c}$$

= where t, c and p are as defined in in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

10.3 Dished and flanged ends for vertical boilers

(Part only shown)

10.3.1 The minimum thickness, *t*, of dished and flanged ends for vertical boilers which are subject to pressure on the concave side and are supported by central uptakes is to be determined by the following formula:

$$\cancel{t = \frac{p\,Ri}{1{,}3\,\sigma} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{p\,R_i}{1{,}3\,\sigma} + c}$$

where

= t, p, c, R_i and σ are as defined in ~~*Vol 2, Pt 1, Ch 3 Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems*~~ *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*.

■ *Section 11*
Furnaces subject to external pressure

11.2 Corrugated furnaces

11.2.1 The minimum thickness, *t*, of corrugated furnaces is to be determined by the following formula:

$$\cancel{t = \frac{10p\,Do}{C} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \frac{10p\,D_o}{C} + c}$$

= where p and c ~~is~~ are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

11.3 Plain furnaces, flue sections and combustion chamber bottoms

(Part only shown)

11.3.1 The minimum thickness, *t*, between points of substantial support, of plain furnaces or furnaces strengthened by stiffening rings, of flue sections and of the cylindrical bottoms of combustion chambers is to be determined by the following formulae the greater of the two thicknesses obtained being taken:

$$\cancel{t = \sqrt{\frac{p\,Do(L+610)}{102\,40}} + 0{,}75\ \text{mm}}$$

$$\boxed{t = \sqrt{\frac{p\,D_o(L\ +\ 610)}{102\,40}} + c}$$

$$\cancel{t = \frac{C\,p\,Do}{110} + \frac{L}{320} + 0{,}75\,mm}$$

$$t = \frac{C\,p\,D_o}{110} + \frac{L}{320} + c$$

= where *t*, *c* and *p* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

11.5 Hemispherical furnaces

(Part only shown)

11.5.1 The minimum thickness, *t*, of unsupported hemispherical furnaces subject to pressure on the convex surface is to be determined by the following formula:

$$\cancel{t = \frac{C\,p\,Ro}{60{,}8} + 0{,}75\,mm}$$

$$t = \frac{C\,p\,R_o}{60{,}8} + c$$

where *t*, *c* and *p* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

11.5.2 In no case is the maximum thickness to exceed 22,5 mm or the ratio $\cancel{\frac{Ro}{t-0{,}75}}$

$$\frac{R_o}{t - c}$$

to exceed 100.

11.6 Dished and flanged ends for supported vertical boiler furnaces

(Part only shown)

11.6.1 The minimum thickness, *t*, of dished and flanged ends for vertical boiler furnaces that are subject to pressure on the convex side and are supported by central uptakes, is to be determined by the following formula:

$$\cancel{t = \frac{p\,Ro}{\sigma} + 0{,}75\,\text{mm}}$$

$$t = \frac{p\,R_o}{\sigma} + c$$

where *c* and *p* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

11.7 Dished and flanged ends for unsupported vertical boiler furnaces

(Part only shown)

11.7.1 The minimum thickness, *t*, of dished and flanged ends for vertical boiler furnaces that are subject to pressure on the convex side and are without support from stays of any kind, is to be determined by the following formula, but is in no case to be less than the thickness of the firebox:

$$\cancel{t = \frac{C\,p\,Ro}{66} + 0{,}75\,\text{mm}}$$

$$t = \frac{C\,p\,R_o}{66} + c$$

where *c* and *p* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

11.8 Ogee rings

(Part only shown)

11.8.1 The minimum thickness, *t*, of the ogee ring which connects the bottom of the furnace to the shell of a vertical boiler and sustains the whole vertical load on the furnace is to be determined by the following formula:

$$\cancel{t = \sqrt{\frac{p\,Di(Di - Do)}{990}} + 0{,}75\,mm}$$

$$t = \sqrt{\frac{p\,D_i(D_i - D_o)}{990}} + c$$

where *t*, *c* and *p* are as defined in *Vol 2, Pt 8, Ch 1, 1.2 Definition of symbols*

Volume 2, Part 8, Chapter 2
Other Pressure Vessels

■ *Section 1*
General requirements

1.2 Definition of symbols

(Part only shown)
1.2.1 The symbols used in the various formulae in *Vol 2, Pt 8, Ch 2, 2 Cylindrical shells and drums subject to internal pressure* to *Vol 2, Pt 8, Ch 2, 7 Standpipes and branches* inclusive, unless otherwise stated, are defined as follows, and are applicable to the specific part of the pressure vessel under consideration:
T = design temperature, in °C~~.~~
c = corrosion allowance in mm for design and operating condition taking into account the intended life cycle; a minimum corrosion allowance of 0,75 mm is to be used, any deviation is to be agreed with LR taking into consideration the material type, service fluid, design and operating conditions. The corrosion allowance is to be added to the calculated Rule thickness as well as to the minimum thickness specified by the Rules.

1.2.2 Where reference is made to calculated or actual plate thickness for the derivation of other values, these thicknesses are to be minus the ~~standard Rule~~ corrosion allowance ~~of 0,75 mm, if not so stated~~ (*c*).

■ *Section 2*
Cylindrical shells and drums subject to internal pressure

2.1 Minimum thickness

(Part only shown)
2.1.1 The minimum thickness, *t*, of a cylindrical shell is to be determined by the following formula:

$$\cancel{t = \frac{pRi}{\sigma\ J - 0{,}5p} + 0{,}75\ \mathrm{mm}}$$

$$\boxed{t = \frac{pR_i}{\sigma\, J - 0{,}5p} + c}$$

where
t, *p*, R_i, *c* and σ are as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*

■ *Section 3*
Spherical shells subject to internal pressure

3.1 Minimum thickness

3.1.1 The minimum thickness, *t*, of a spherical shell is to be determined by the following formula:

$$\cancel{t = \frac{pRi}{2\sigma\ J - 0{,}5p} + 0{,}75\ \mathrm{mm}}$$

$$\boxed{t = \frac{pR_i}{2\,\sigma\, J - 0{,}5p} + c}$$

where *t*, *p*, *R*~~-~~$_i$, σ, *c* and *J* are as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*.

■ *Section 4*
Dished ends subject to internal pressure

4.1 Minimum thickness

(Part only shown)
4.1.1 The thickness, *t*, of semi-ellipsoidal and hemispherical unstayed ends, and the knuckle section of torispherical ends, dished from plate, having pressure on the concave side and satisfying the conditions listed below, is to be determined by the following formula:

$$\cancel{t = \frac{p\ Do\ K}{2\ \sigma\ J} + 0{,}75\ \mathrm{mm}}$$

$$\boxed{t = \frac{p\,D_o\,K}{2\,\sigma\,J} + c}$$

where
= *t*, *p*, D_o, *c* and *J* are as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*

4.1.4 In addition to the formula in *Vol 2, Pt 8, Ch 2, 4.1 Minimum thickness 4.1.1* the thickness, *t*, of a torispherical head, made from more than one plate, in the crown section, is to be not less than that determined by the following formula:

$$\cancel{t = \frac{pRi}{2\,\sigma\,J - 0{,}5p} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{pR_i}{2\,\sigma\,J - 0{,}5p} + c}$$

where *t*, *p*, R_i, σ, *c* and *J* are as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*.

■ *Section 6*
Conical ends subject to internal pressure

6.2 Minimum thickness

(Part only shown)
6.2.1 The minimum thickness, *t*, of the cylinder, knuckle and conical section at the junction and within the distance *L* from the junction is to be determined by the following formula:

$$\cancel{t = \frac{p\,Do\,K}{2\,\sigma\,J} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{p\,D_o K}{2\sigma\,J} + c}$$

where *t*, *p*, σ, *c* and *J* are as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols.*

(Part only shown)
6.2.3 The minimum thickness, *t*, of those parts of conical sections not less than a distance *L* from the junction with a cylinder or other conical section, is to be determined by the following formula:

$$\cancel{t = \frac{pD_c}{2\sigma J - p\cos\alpha}\frac{1}{\ } + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{pD_c}{2\sigma J - p\cos\alpha}\frac{1}{\ } + c}$$

where
α, α_1, α_2 = angle of slope of conical section (at the point under consideration) to the vessel axis, *see Figure 1.5.1 Conical ends and conical reducing sections* in *Vol 2, Pt 8, Ch 1 Steam Raising Plant and Associated Pressure Vessels*~~.~~
c is as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*.

■ *Section 7*
Standpipes and branches

7.1 Minimum thickness

(Part only shown)
7.1.1 The minimum wall thickness, *t*, of standpipes and branches is to be not less than the greater of the two values determined by the following formulae, making such additions as may be necessary on account of bending, static loads and vibrations:

$$\cancel{t = \frac{p\,Do}{2\,\sigma\,J + p} + 0{,}75\text{ mm}}$$

$$\boxed{t = \frac{p\,D_o}{2\,\sigma\,J\,+\,p} + c}$$

where *t*, *p*, D_o, *c* and σ are defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*.

■ *Section 10*
Hydraulic tests

10.1 General

(Part only shown)

10.1.1 Pressure vessels covered by this Chapter are to be tested on completion to a pressure, p_{-T}, determined by the following formula, without showing signs of weakness or defect:

$$\cancel{p_T = 1{,}3 \frac{\sigma_{50}}{\sigma_T} \frac{t}{(t-0{,}75)} p}$$

$$\boxed{p_T = 1{,}3 \frac{\sigma_{50}}{\sigma_T} \frac{t}{(t-c)} p}$$

but in no case is to exceed

$$\cancel{1{,}5 \frac{t}{(t-0{,}75)} p}$$

$$\boxed{1{,}5 \frac{t}{(t-c)} p}$$

where

σ_{50} = allowable stress at 50°C, in N/mm^2~~,~~

c = corrosion allowance as defined in *Vol 2, Pt 8, Ch 2, 1.2 Definition of symbols*.

Volume 2, Part 9, Chapter 1
General Requirements for the Design and Construction of Electrotechnical Systems

■ *Section 1*
General requirements

1.3 Definitions

1.3.27 A ‘secondary lithium cell’ is a cell where electrical energy is derived from the insertion/extraction reactions of lithium ions or oxidation/reduction of lithium between the negative electrode and the positive electrode. These may be combined in ‘cell blocks’ consisting of a group of cells connected together in a parallel configuration.

1.3.28 A ‘battery module’ is an energy storage device comprising one or more electrically connected cells or cell blocks. The battery module can include protective and monitoring devices.

1.3.29 A **‘**battery pack’ is an energy storage device comprising one or more electrically connected cells, cell blocks or modules. The battery pack can include protective devices and control and monitoring systems which communicate with the battery management system.

1.3.30 A ‘battery management system (BMS)’ is an electronic system which monitors and manages the state of a cell, battery module or battery pack in order to maintain the battery system in a safe operating state and protect it in cases of overcharging, over current and overheating and communicates with an external charge/discharger controller.

1.3.31 A ‘lithium battery system’ is a system comprising one or more lithium battery modules or packs incorporated in a fixed installation together with means of isolation, a cooling system (if provided) and has an associated BMS. .

1.3.32 ‘State of charge (SOC)’ is the available capacity in a battery expressed as a percentage of rated capacity.

1.3.33 ‘State of health (SOH)’ reflects the general condition of a battery expressed as a percentage of ability to deliver the specified performance compared with that of a new battery.

1.3.34 ‘Battery space’ is the space or compartment in which a battery is installed.

1.4 Documentation required for design review

(Part only shown)

1.4.2 A description of operation (with explanatory diagrams), schematic diagrams of circuits~~,~~ and lists of monitored parameters with relevant set points:

- Electric generating plant.
- Lithium battery system installations.
- ~~Waterjets~~ Water jets for propulsion purposes.

1.4.27 **Lithium battery systems**. In addition to the plans and information required by *Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review 1.4.2*, the following information is also to be submitted:

(a) System functional description including all operating modes (i.e. charging, discharging, standby, backup, peak shaving, etc.), safety functions and their hierarchy, and expected battery system behaviour in case of malfunction.
(b) Technical description detailing how safety information from type testing has been considered in the actual installation design.
(c) Integration plan for the battery system with the vessel power distribution and charging arrangements.
(d) Line diagrams of the battery system control and power distribution, including switchgear, protective devices, control gear and emergency trip (E-Trip) as well as interfaces to external systems.
(e) A Failure Mode and Effects Analysis (FMEA) and mitigation strategy, which is to be carried out for the battery installation as a whole in accordance with IEC 60812*: Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*, or an equivalent and acceptable National or International Standard and the report and worksheets are to be submitted for consideration.
(f) Arrangement plans of any HVAC, ventilation, cooling system and drains for the battery space.
(g) Fire detection, alarm and extinguishing system (including portable fire-fighting appliances) plans for the battery space.
(h) A schedule of electrical equipment for use in the battery space and HVAC, ventilation and cooling system giving details of the appropriate type of protection for the temperature class and gas group of the potential gases. Copies of appropriate certification are to be submitted for consideration.
(i) Arrangement plans for electrical equipment showing cable routes associated with the battery system, power distribution and E-Trip.
(j) General arrangement plan showing hazardous zones for the battery space, including the HVAC, ventilation, cooling system and drains.
(k) Fire integrity plans for the battery space (including penetrations drawings), contiguous spaces and means of escape from the battery space.

1.5 Documentation required for supporting evidence

1.5.12 **Lithium battery systems.** In addition to the plans and information required by *Vol 2, Pt 9, Ch 1, 1.4.27 Documentation required for design review*, the following information is also to be submitted:

(a) Document outlining the operational limits for the battery system
(b) Operation, maintenance and training manuals for the battery system are to be kept on board including:
   (i) Manual that describes the standard operating, maintenance and emergency procedures for the system;
   (ii) Testing procedures including Annual Survey test requirements (*see Vol 2, Pt 9, Ch 12, 1 Testing and trials*, *Table 12.1.3 Test requirements on lithium battery systems*);
   (iii) Through life management plan for the battery system, including disposal.

Volume 2, Part 9, Chapter 2
Electrical Power Generator and Energy Storage

■ *Section 7*
Batteries

7.1 General requirements

7.1.1 The requirements of this Section apply to aqueous and non-aqueous permanently installed secondary batteries of the vented and valve-regulated sealed type.

- **Goal**
  Safe energy storage and dependable supply of power to consumers.
- **Functional requirements**
  Reasonably foreseeable hazards external to the battery shall be identified and managed.
  Reasonably foreseeable hazards internal to the battery shall be identified and managed.

7.1.4 The following Sections apply to lead acid, ~~and~~ nickel cadmium and lithium cell chemistries. While some of the same mitigations would be applicable, fixed charging stations for portable lithium batteries are not covered by these requirements due to differences in both design and arrangements. Where other cell chemistries or arrangements are to be used, then a Risk Assessment is to be carried out in accordance with the requirements of *Vol 2, Pt 1, Ch 3, 18 Risk Assessment (RA)*. The Risk Assessment is to include, but is not limited to:

- cell type;
- battery construction;
- the battery management;
- location;
- ventilation requirements;

- installation; and
- fire.

7.1.5 Lithium battery systems are to be Type Approved in accordance with LR's *Type Approval System Test Specification Number 5 (2019),* or alternatively manufactured and tested to assess compliance with the applicable International or National Standards, and application of an acceptable quality management system, may be submitted for consideration.

7.1.6 The battery management systems are to be Type Approved in accordance with LR's *Type Approval System Test Specification Number 1 (2018), or alternatively manufactured and tested to assess compliance with the applicable International or National Standards, and application of an acceptable quality management system, may be submitted for consideration.*

7.1.7 Where the lithium battery total system installation is less than 20 kWh then it is to be housed in a gastight steel enclosure with a gastight ventilation duct leading to a safe space on open deck and is to be suitable for withstanding the temperatures and pressures generated in the worst case thermal runaway condition. The battery system is to satisfy the requirements of LR's Type Approval System *Test Specification Number 5 (2019)*, or an equivalent and acceptable National or International Standard, amended where necessary for a battery space ambient temperature of 45°C. Alternative arrangements are subject to special consideration.

7.1.8 The following Sections apply to lithium battery system installations of a capacity 20 kWh or greater and are in addition to those applicable in other Parts of these Rules:
- *Vol 2, Pt 9, Ch 2, 7.1 General requirements 7.1.9*;
- *Vol 2, Pt 9, Ch 2, 7.2 Design and construction 7.2.2* to *Vol 2, Pt 9, Ch 2, 7.2 Design and construction 7.2.6*;
- *Vol 2, Pt 9, Ch 2, 7.3 Location 7.3.11*;
- *Vol 2, Pt 9, Ch 2, 7.4 Installation 7.4.5* to *Vol 2, Pt 9, Ch 2, 7.4 Installation 7.4.9*;
- *Vol 2, Pt 9, Ch 2, 7.5 Thermal management and ventilation 7.5.7* and *Vol 2, Pt 9, Ch 2, 7.5 Thermal management and ventilation 7.5.11*;
- *Vol 2, Pt 9, Ch 12, 1.1 Testing 1.1.6.*

7.1.9 For lithium battery system installations of nominal voltages exceeding 1500 V d.c., a Risk Assessment is to be carried out in accordance with the requirements of *Vol 2, Pt 1, Ch 3, 18 Risk Assessment (RA)*.

7.1.10 Integration of a lithium battery system that satisfies a ship's main power demand into the ship's electrical power system is to be in accordance with *Vol 3, Pt 1, Ch 6 Hybrid electrical power systems*.

7.2 Design and c~~C~~onstruction

7.2.2 A Failure Mode and Effects Analysis (FMEA) is to be carried out for the lithium battery system installation and is to consider the effects of failure upon safety and dependability of the lithium battery system installation, taking account of reasonably foreseeable internal and external failures such that the goal and functional requirements of *Vol 2, Pt 9, Ch 2, General requirements 7.1.1* are achieved and is to include but is not limited to the following:
(a) overpressure, fire and explosion;
(b) electrical short circuit due to leakage of cell electrolyte or mechanical impact;
(c) venting out flammable and toxic gases;
(d) rupture of the casing of cell, battery module, battery pack or battery system with exposure of internal components; and
(e) ingress of water into the battery space from cooling system leak, fire suppression system release and/or adjacent areas.

7.2.3 The casing of a lithium cell and/or battery module is to incorporate pressure relief functions that will prevent overpressure, rupture or explosion of the battery module enclosure (*see Vol 2, Pt 9, Ch 12, 1 Testing and trials*).

7.2.4 The lithium battery management system is to continuously monitor the condition of cells, battery modules or battery packs and to maintain them within their specified safe operating region. As a minimum the alarms and safeguards as indicated in *Table 2.7.1 Lithium battery system: alarms and safeguards* are to be provided:

Table 2.7.1 Lithium battery system: alarms and safeguards

Item	Alarm	Note
Cell voltage*	High	Automatic termination of the cell charge current. *See* Notes 1 and 5
	Low	Per cell. Automatic prevention of cell discharge. *See* Notes 2 and 5
Cell temperature*	1st stage high	Per sensor. *See* Notes 4 and 5
	2nd stage high	Per sensor. Automatic shutdown of battery system. *See* Notes 4 and 5
	Low	Automatic charge and discharge current limitation. *See* Notes 3 and 4
Charge current of the battery cells	High	Automatic reduction of charge/discharge current. *See* Note 3
Communication failure between battery management system and external charge controller system	Failure	Automatic shutdown of battery system *See* Note 6
Battery management system	Failure	Automatic shutdown of battery system
Temperature sensor	Failure	Automatic shutdown of battery system
Voltage sensor	Failure	Automatic shutdown of battery system

Emergency trip*	Active	Automatic shutdown of battery system *See* Note 5
Insulation resistance	Low	-

Note 1. Cell voltage is to be maintained below the cell manufacturer specified upper limit charge voltage.

Note 2. Cell voltage is to be maintained above the cell manufacturer specified lower limit discharge voltage.

Note 3. Cell charge/discharge current is to be controlled within cell manufacturer specified current limits.

Note 4. Cell temperature is to be controlled within the cell manufacturer specified temperature limits.

Note 5. For lithium batteries used for Mobility systems, Ship Type systems, Ancillary systems or emergency services, only items marked * are to initiate automatic shutdown.

Note 6. For lithium batteries used as an emergency source of power, communication failure is to automatically stop and prevent charging.

Footnote: Automatic shutdown of battery system includes termination of battery charging and discharging and disconnection from electrical distribution network.

7.2.5 A fully independent hard-wired means to disconnect the battery system in an emergency from power distribution is to be provided. This emergency trip is to be located outside of the battery space and situated such that it will remain accessible in the event of an emergency inside the battery space and is to initiate an audible and visual alarm at the relevant control stations to advise duty personnel of the emergency condition.

7.2.6 For lithium battery system installations the following is to be measured and displayed at relevant manned control stations:
(a) State of charge (SOC) and state of health (SOH) are to be displayed at relevant control stations and on the navigating bridge.
System alarms are to be displayed at relevant control stations and at least a common alarm displayed on the navigating bridge.

7.3 Location

7.3.11 The lithium battery space is not to be located forward of the collision bulkhead and is not to be contiguous to the boundaries of machinery spaces of Category A or those spaces containing the main source of electrical power, associated transforming equipment (if any) or the main switchboard. The boundaries of the lithium battery space are to be part of a vessel structure or enclosures and provided with ‘A-60’ insulation of the bulkhead unless the space is adjacent to spaces of negligible fire risk such as cofferdams, void spaces, or similar in which case consideration can be made to reduce the insulation to ‘A-0’. Penetrations through these boundaries are to be protected to the same fire protection standard. Special consideration will be made for a ship not built of steel or equivalent material. All other safety systems within the lithium battery spaces are to be in accordance with the requirements of this Part or, if not made explicit, at least equivalent to those of a machinery space of Category A.

7.3.12 Approaches to protect equipment within critical compartments from representative fragmentation and small arms threats are described in optional notations, *see Vol 1, Pt 4, Ch 2, 4 Fragmentation protection.*

7.4 Installation

7.4.5 Battery systems are to be installed in accordance with manufacturer’s recommendations taking account of the results of the risk assessment or FMEA, where applicable.

7.4.6 The lithium battery space and the crates, trays, boxes, shelves and other structural parts therein are to be designed and constructed such that the structural integrity of the battery space will not be compromised in the event of a lithium fire.

7.4.7 The lithium battery space is to be fitted with suitable fixed detectors in accordance with manufacturer’s recommendations and which are capable of providing early identification of a fire or thermal runaway condition. Early identification is to include high cell temperature or detection of electrolyte solvent vapours and a combination of smoke and heat detectors. When activated, the fire detection system is to initiate an alarm to the relevant control stations and on the navigating bridge and is to initiate the automatic isolation of electric systems within the lithium battery space, except as described below, and activate the fixed fire-fighting system.

7.4.8 In the event that a fire or thermal runaway condition is identified, the battery monitoring system is to initiate protective features such as automatic safe isolation of the batteries. Ventilation necessary for extraction of gasses, active cooling systems, and thermal/safety monitoring and alarm are to be continued prior to, during and after an overheating or fire event. Failure of the monitoring system is to be alarmed to the ship’s safety system and is to result in the battery system automatically reverting to a defined safe state.

7.4 9 An appropriate water-based fixed fire-fighting system in accordance with SOLAS II-2, Part C, Regulation 10.4.1.1.3 and the manufacturer’s recommendation is to be provided for the lithium battery space. The fixed fire-fighting system is to be

suitable for heat removal, boundary cooling and/or extinguishing for the duration that the heat and/or gas release are present. Fixed fire-fighting systems using a medium other than water which provide equivalent heat removal, boundary cooling and/or extinguishing for the duration that the heat and/or gas release is present can be taken into consideration provided that appropriate fire tests have been conducted. In particular, the fire-extinguishing media are to be chosen as appropriate for the specific type and characteristics of fire foreseen.

7.4.10 The fixed fire-fighting control system is to be located outside the battery space, be activated automatically and be capable of manual activation. In addition to the fixed fire-fighting system, the battery space is to be provided with a minimum of two (2) portable and suitable fire-extinguishers located outside the space at or near the entrance(s) and in agreement with the Naval administration/authority. The number and position of hydrants are to be such that at least two jets of water not emanating from the same hydrant, each from a single length of hose, can reach any part of the lithium battery space. Such hydrants are to be positioned in close proximity to the lithium battery space. Any part of the fire-fighting system which crosses through the lithium battery space without serving it is to be avoided.

7.4.11 The fire detection and automatic water-based fire-fighting systems are to be in accordance with the recommendations of the battery manufacturer and the following sub-Sections of these Rules:

- *Vol 2, Pt 9, Ch 9, 4.1 General*;
- *Vol 2, Pt 9, Ch 9, 5.1 Automatic sprinkler system;*
- *Vol 2, Pt 9, Ch 9, 5.2 Fixed water-based local application fire-fighting systems*;

7.4.12 The technical description detailed in *Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review, 1.4.27* is to consider the actual battery system installation and its integration into the ship, including but not limited to the following:

- arrangement of battery compartment (location, including fire risk of adjacent spaces/compartments, fire burden from equipment other than batteries, heat sources, etc.);
- temperature control arrangements for the battery space and their contribution to system safety;
- ventilation arrangements to prevent concentrations of gasses within the space in case of uncontrolled thermal runaway;
- hazardous area(s) requirements;
- reasonable gas tightness of ventilation ducting;
- fire integrity of the space;
- the use of fire extinguishing arrangements for cooling in the case of uncontrolled thermal runaway.

The FMEA referenced in *Vol 2, Pt 9, Ch 2, Design and construction, 7.2.2* should address any additional failure modes identified during the preparation of this technical description.

7.4.13 The lithium battery space is to be provided with two means of escape, at least one independent of any watertight door and leading to a safe position outside the space. One of the escapes is to be suitable for the passage of a stretcher. At each entrance/exit an emergency escape breathing device (EEBD) is to be provided. Where the maximum travel distance to the door within the lithium battery space is less than 5 m, a single means of escape is acceptable. The lithium battery space is not to be considered as part of an escape route (primary or secondary) from any other accommodation, control, service space, machinery space of Category ‘A’ and high fire risk area such as a garage, paint store, etc.

7.5 Thermal management and ~~v~~Ventilation

7.5.7 Ventilating fans for battery compartments are to be so constructed and be of material such as to minimise risk of sparking in the event of the impeller touching the casing, and are to be suitable for the potentially hazardous and corrosive gases produced in a thermal runaway condition. Non-metallic impellers are to be of an anti-static material.

7.5.11 Thermal management of the lithium battery space is to be assessed, including the criticality of any cooling systems required to ensure reliable operation and to prevent thermal runaway within the marine environment. *See also Vol 2, Pt 9, Ch 1, 1.5 Documentation required for supporting evidence 1.5.4.*

Volume 2, Part 9, Chapter 12
Testing and Trials

■ *Section 1*
Testing and trials

1.1 Testing

1.1.6 Tests at the manufacturers’ works and trials after installation on board are to include such tests necessary to demonstrate, to the Surveyor’s satisfaction, the suitability and safety of the lithium battery system for its intended duty and location. As a minimum, the tests listed in *Table 12.1.3 Test/Trials requirements on lithium battery systems* are required.

Table 12.1.3 Test/Trials requirements on lithium battery systems

Item	Tests	Trials
Discharge performance validation	X	
Capacity validation test *	X	X
Internal DC resistance test	X	
Overcharge control test	X	
Cell balancing functional test	X	
Sensor failures test	X	
SOC validation test *	X	X
SOH validation test *	X	X
High voltage test	X	
Insulation resistance test	X	
Emergency trip functional test *	X	X
Over-temperature protection test	X	X
Over-voltage protection test	X	X
Under-voltage protection test	X	X
Communication failure between BMS and external charge control system test *	X	X
Pressure relief valve test	X	
Additional safety functions tests and trials of the battery management system	X	X
Note. Items marked * are required to be tested annually.		

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